Heritage College

Sunnyside Groundwater Study
Final Report

August 13, 2003

Acknowledgements

This report is dedicated to all of the Heritage College students and staff who labored to complete this work in the face of many obstacles. In spite of the adverse environment they were exposed to, these students and staff prevailed in their tasks until the study was complete. They are listed in alphabetical order below:

Benny Alsonso
Sara Ehmer
Pat Falco
Daniel Juarez
Irma Lange
Katherine Zapel

The community owes them a debt of gratitude for their unselfish labor and contributions to the understanding of groundwater quality in the lower Yakima Valley.

Summary

Heritage College has conducted a field investigation of groundwater quality in the area extending from Zillah to Sunnyside Washington. The study area contains approximately 300 mi^2 of land from the east back of the Yakima River to the edge of the irrigated land further east. This area contains at least 89 dairies and feedlots. Monthly sampling campaigns were conducted from June 2001 to October 2002. In the initial survey, we measured the concentrations of nitrate-nitrite-nitrogen (NO_3-NO_2-N) Phosphate (PO_4), total dissolved solids (TDS), dissolved oxygen (DO), and alkalinity.

In subsequent surveys, we reduced the number of measurements by reducing the frequency of PO_4, DO and alkalinity concentration measurements because these measurements do not contribute much useful information about the aquifer. The first survey demonstrated that the concentration of these substances were fairly uniform across the aquifer in the study area. We also measured groundwater temperature and pH in all surveys. In addition to these periodic tests, we tested most of the participants' wells for the presence of total coliform bacteria. We believe the information collected characterizes the water quality of the regional aquifer during the irrigation season.

There are three major conclusions from these surveys. The first conclusion is that concentrations of NO_3-NO_2-N are elevated in 3 areas of region as shown in Figure 1. The second major

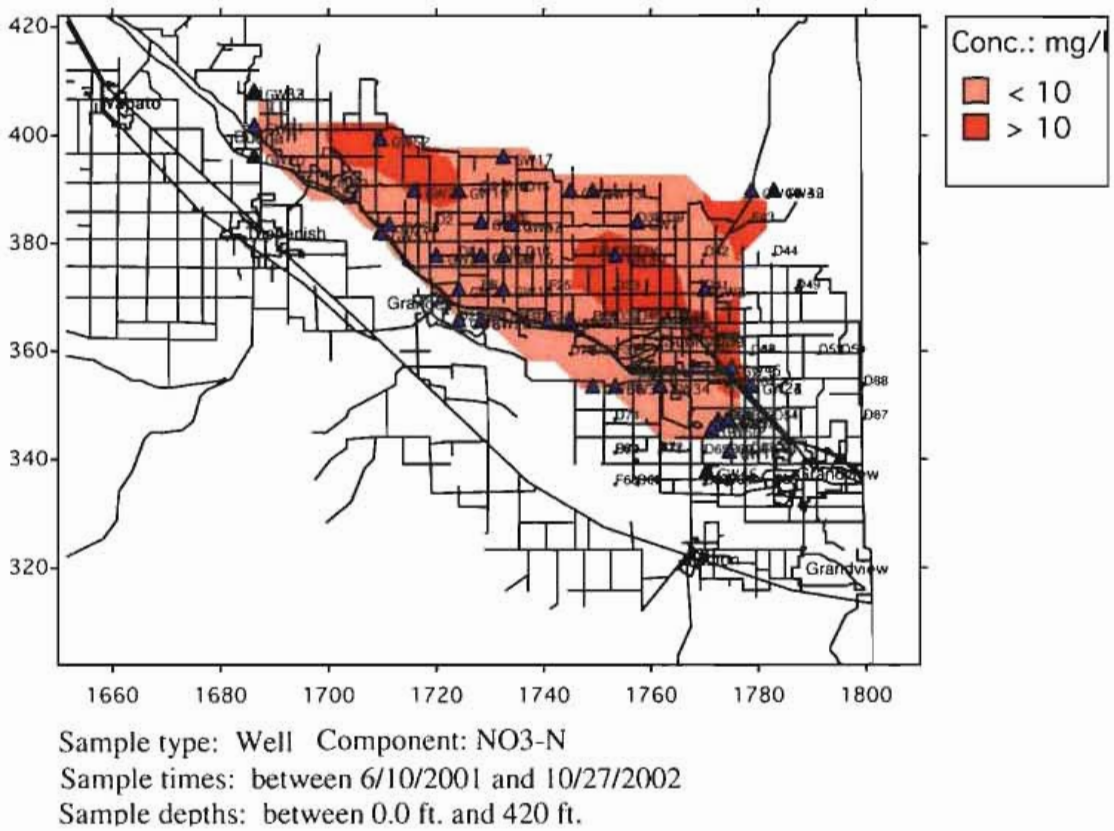
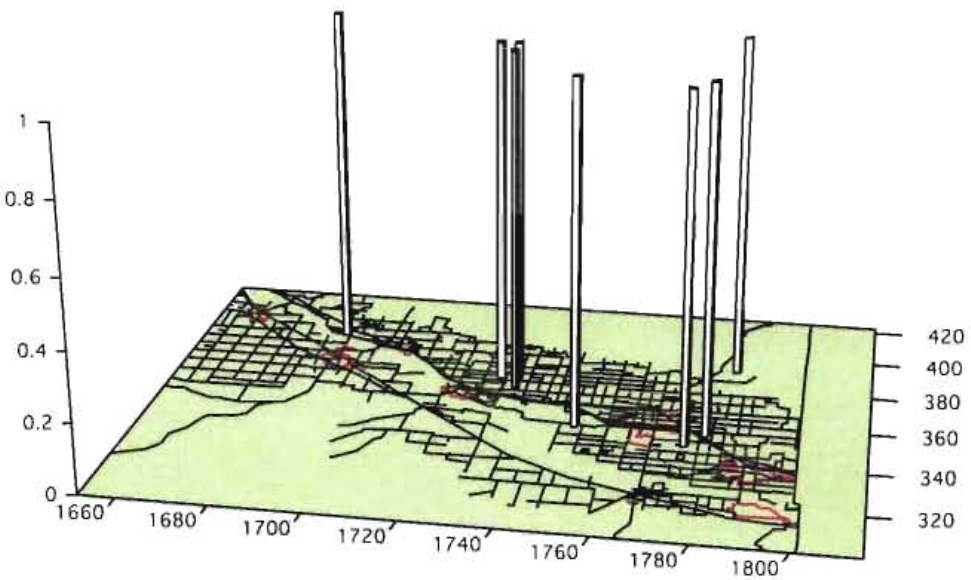


Figure 1: Contour Plot of Mean NO_3-N Concentrations Campaign

conclusion is that there are coliform bacteria present in a significant number of wells in the region as shown in Figure 2. The locations of wells that test positive for total coliforms are in areas of high groundwater NO_3-NO_2-N concentrations. The source of these bacteria can only be animal feces. Consequently, these results suggest that sources of contaminants are feedlots and or dairy operations.

The third conclusion we have reached is that the concentration of TDS is correlated with NO_3-NO_2-N concentration. Figure 3 shows a plot of TDS concentrations versus NO_3-NO_2-N concentrations illustrating this correlation. Figure 4 shows isopleths of TDS concentrations that exhibit the same pattern of elevated concentrations shown for NO_3-NO_2-N concentrations shown in Figure 1.

In addition to the major conclusion we have drawn, we also noted that the concentration of NO_3-NO_2-N has risen by a small amount during the first irrigation season. Based on the outcome of this first monitoring period, we planned to monitor the same sites through the season in which irrigation water is not used. We did not expect the groundwater quality to change remarkably during this period. Over the entire period of the study, NO_3-NO_2-N concentrations rose slightly.



Sample type: Well
Component: FECAL_COL
Sample times: t between 6/26/2001 and 9/8/2001
Sample depths: between 0 ft and 420 ft

Figure 2: Skyscraper Plot of Positive Fecal Coliform Tests, A Value of 1 on the Vertical Axis Indicates a Positive Result

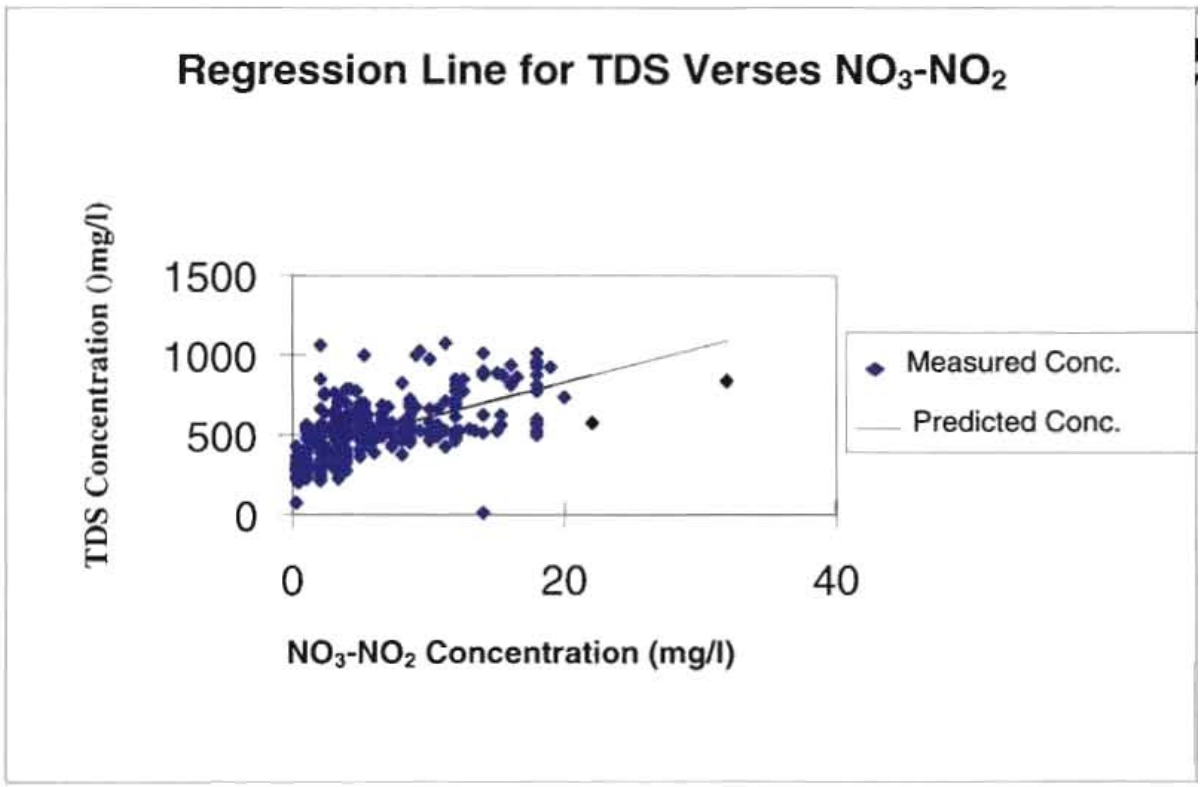


Figure 3: Correlations Between TDS Concentration and NO_3-NO_2 Concentration

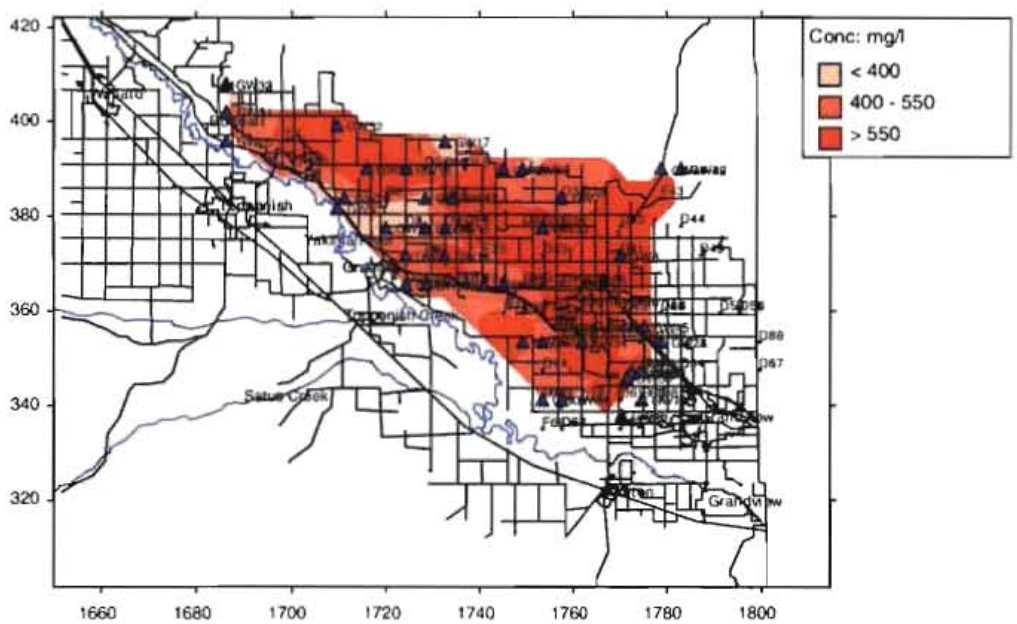


Figure 4: Contour Plot of Mean Total Dissolved Solids Concentrations

In addition to the monitoring studies, Heritage College has distributed fact sheets published by the Washington State Department of Health concerning the risks of exposure to elevated levels of nitrogen and exposure to coliforms. These fact sheets also contain information on remedial measures that can be taken to alleviate these risks. We also distributed a Spanish language version of the fact sheet to Spanish speaking members of the community. We have noted that installation of filters eliminates coliform bacteria and reduces NO_3-NO_2-N concentrations below the regulatory level of concern, 10 ppm. All participants in the study whose well water NO_3-NO_2-N concentrations are above 10 ppm or contained coliforms now have installed filters. Since the installation of these filters, no participant's drinking water contains over 10 ppm NO_3-NO_2-N or coliforms.

Introduction

Initial aspects of the study involved literature surveys and consultation with regional offices of public agencies in the area. We contacted the local or regional offices of the U.S. Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), the Washington Department of Ecology (DOE), the Washington Department of Health, the Sunnyside Irrigation District and the Sunnyside Port Authority. We determined from the literature survey and consultations that no general groundwater study had been conducted in the area.

The USGS has such a study planned but has not begun sampling yet. The Port of Sunnyside has collected groundwater data in the immediate vicinity of their treatment plant but it covers a very small area. EPA was helpful in providing a number of technical reports containing information on the design and conduct of groundwater studies and quality assurance guidance.

Upon completion of the review, Heritage staff defined criteria for selection of groundwater sampling locations. These criteria were

- A well that can be sampled must be located on the property of the participants
- The location of the property matched the needs of the study to sample up gradient and down gradient of dairy operations located in the area.
- Participants had to be willing to sign a consent form giving access to Heritage College employees to the well.

Heritage staff then surveyed residents in the area to solicit participants in this study. Approximately 100 participants were identified and signed consent agreements. A copy of the agreement is attached to this report as Appendix A. Next, the locations of all known dairies and feedlots in the proposed study area were surveyed using a global positioning system (GPS). Longitude, latitude, and elevation were recorded. The locations of these sites are shown in Figure 5.

Of the 100 potential participants, 45 were selected using the criteria shown above. Throughout the progress of the study, several participants decided to end their participation in the program. We selected additional participants as replacements from the list of potential participants. We chose replacements to maintain the geographic distribution of wells reflected in the original design of the study. The locations of the wells of all the participants were surveyed using a GPS. Longitude, latitude, and elevation were recorded. The locations of these sites are shown in Figure 6.

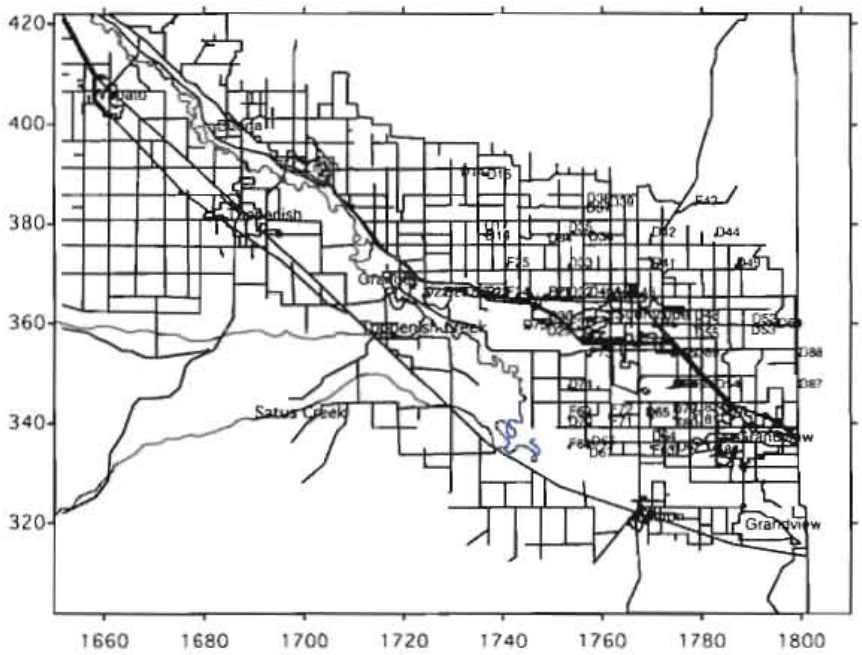


Figure 5: Locations of Dairies and Feedlots in the Study Area

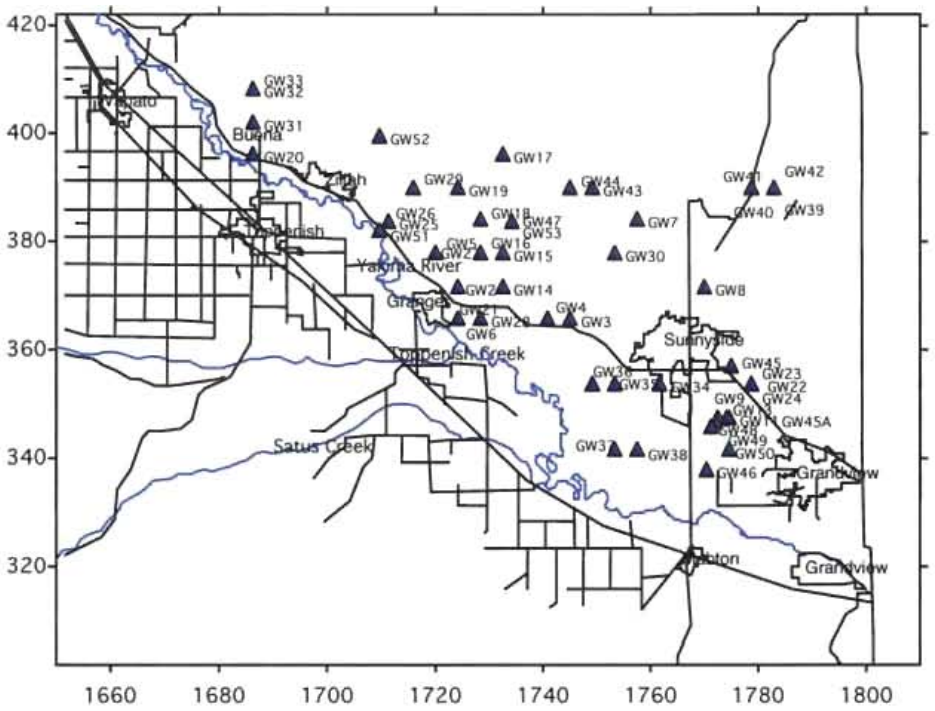


Figure 6: Sampling Locations

Methods

Methods selected for measuring the concentrations of NO_3-NO_2-N, PO_4, TDS, DO, and alkalinity in the field were adopted from *The Globe Program Teachers Guide*, (1997). An Enviro-Safe thermometer was used to measure water temperature, an Oakton pH meter was used to measure pH and an Oakton conductivity meter was used to measure TDS. Figure 7 shows typical results for the NO3 field kit.

Nitrate within EPA Standards

Comparison of low and high levels of Nitrate.

Figure 7: Results of Nitrate-N Analysis Using Field Kit

In the case of NO_3-NO_2-N, a confirmatory laboratory test procedure was also selected. It is the cadmium reduction procedure described in Standard Methods for the Examination of Water and Wastewater (1980) published by the American Public Health Association. A qualitative test to determine the presence of coliform bacteria was also selected. The method used is described by LaMotte (2001). Figure 8 shows typical test results using this kit.

Before implementing the field study, a sampling and NO_3-NO_2-N, PO_4, TDS, DO, temperature, pH, coliforms, and alkalinity protocols was established. These protocols are attached to this report as Appendix B. Appendix C contains the quality assurance procedures. The sampling protocol required that:

- samplers and laboratory analysts always work in pairs
- sampling containers and any other glassware used must be acid washed
- water systems to be sampled must be flushed for a minimum of 5 minutes
- samples transported to the laboratory must be packed in ice and stored samples must be kept at 4 ^{0}C
- All samples must be analyzed within 24 hours of collection.

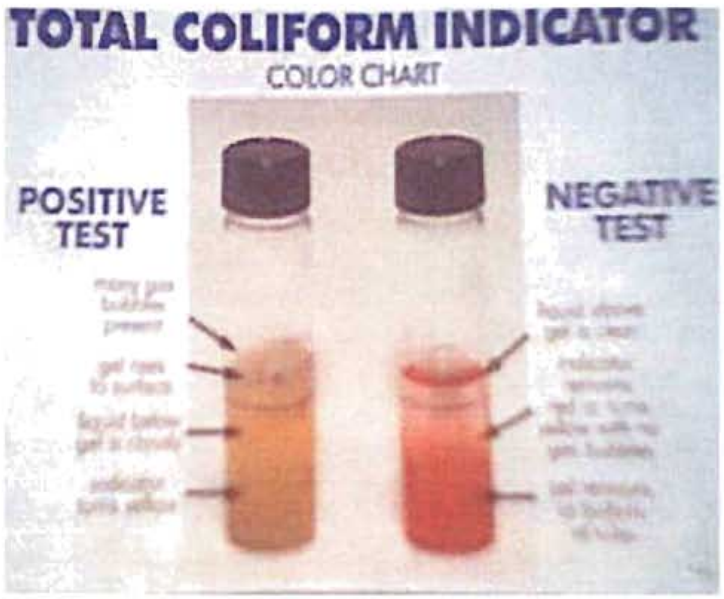


Figure 8: Example Results of Total Coliform Tests

To determine weather or not measured concentrations of constituents varied over the three periods investigated, the following procedure was implemented.

- Data sets were separated in to three data sets. The first data set contained all data collected on or before September 6, 2001. The second data set contained all measurements reported

after September 6, 2001 and on or before April 6, 2002. The third data set contained measurements reported after April 6, 2002 until the end of the study on October 10, 2002.

- Histograms showing the cumulative frequencies of occurrence of NO_3-NO_2-N, TDS, DO concentrations, pH, and water temperature were prepared for each period and compared.

- The standard deviations, mean values and 95% confidence intervals of NO_3-NO_2-N, TDS, DO concentrations, pH, and water temperature for each period were calculated and compared.

- z-tests to determine if there were significant difference in the means of NO_3-NO_2-N, TDS, DO concentrations, pH, and water temperature for each period were carried out per the procedure outlined by Bluman[1].

Results

Over the course of the study, we sampled 54 wells. Forty to forty-five wells were sampled in each campaign during the summer. Fewer wells were sampled in the winter because many of them were taken out of service for that season. As indicated in the summary, we discovered three distinct areas that exhibited high NO_3-NO_2-N. Coliforms have been found in well water at sampling sites in these three areas as previously shown in Figure 2.

The data collected over the course of the study have been stored in a database. A geographical information system (GIS) SiteAnalyzer has been used to depict the level and extent of chemical concentrations, temperatures, pH and results of total coliform tests reported in this database. Depictions were made reflecting variations in NO_3-NO_2 concentrations during the first irrigation season, during the period from the beginning of the study until the end of season in which irrigation water was not applied to fields and for the entire duration of the study. Figure 9 through 14 show the average and maximum concentrations of parameters measured at the sampling locations during these periods. Depictions of dissolved oxygen concentrations, ground water temperature, pH, and concentrations of total dissolved solids were made reflecting during the first irrigation season, during the period in which irrigation water was not applied to fields and for a second irrigation season. Figure 15 through 35 show the average and maximum concentrations of parameters measured at the sampling locations during these periods. Table D in Appendix D contains a copy of the chemical concentrations, pH, groundwater temperature, and results of total coliform tests performed.

[1] Allen G. Bluman, **Elementary Statistics: A Brief Version.** pp. 377-382, McGraw Hill, Boston, 2000.

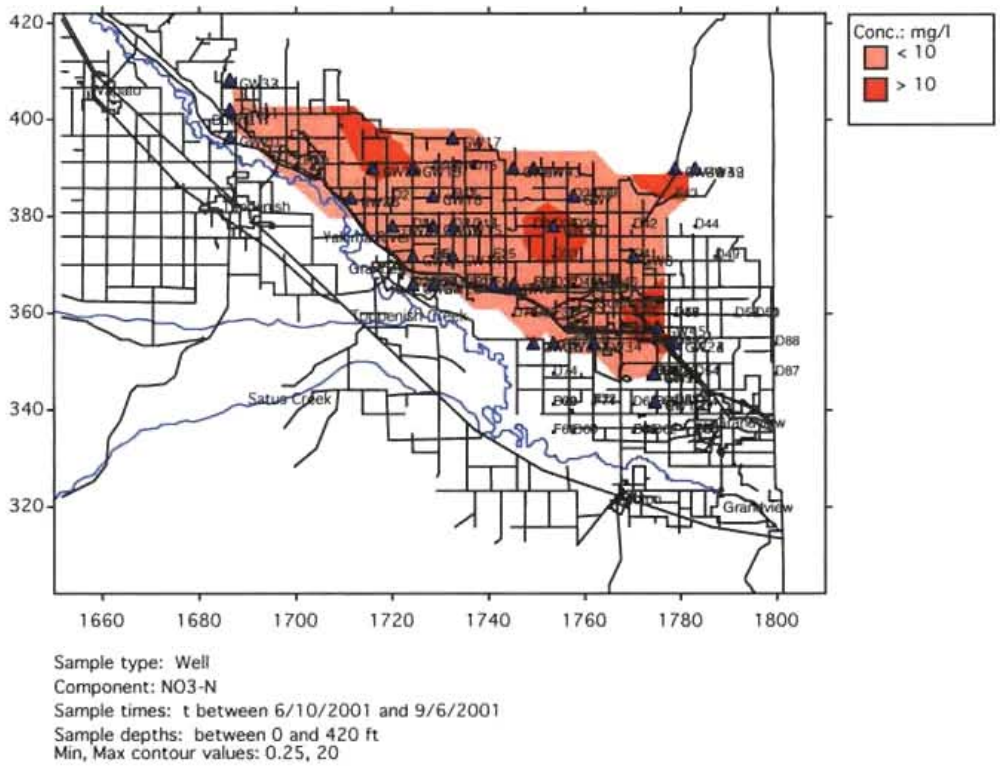


Figure 9: Contours of Maximum NO_3-NO_2 Concentrations Between 6/10/01 to 9/06/01

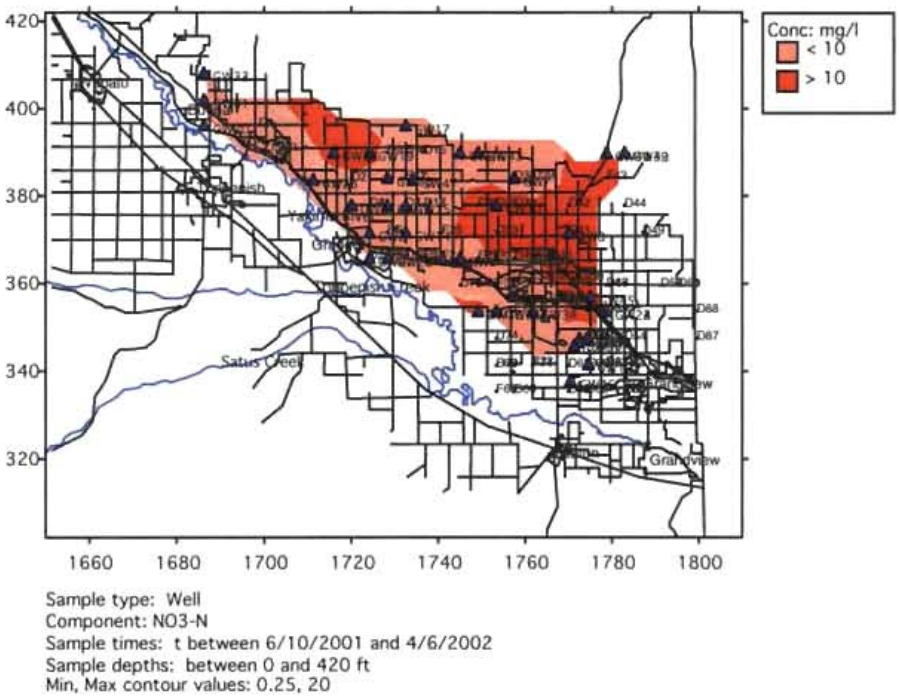


Figure 10: Contours of Maximum NO_3-NO_2 Concentrations Between 6/10/01 to 4/04/02

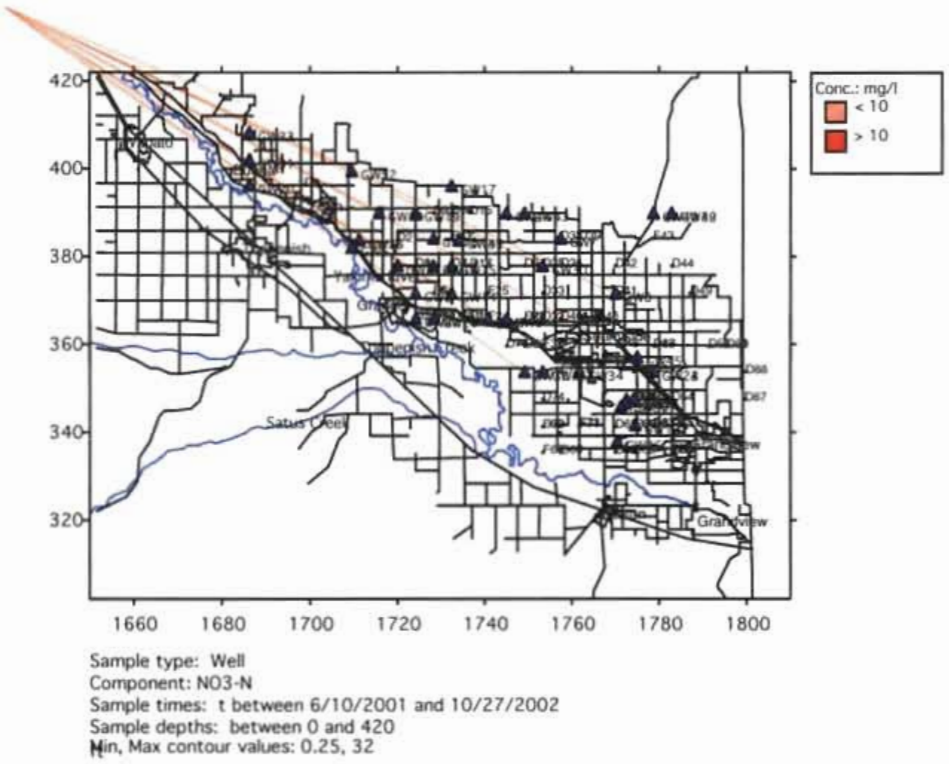


Figure 11: Contours of Maximum NO_3-NO_2 Concentrations Between 6/10/01 to 10/27/02

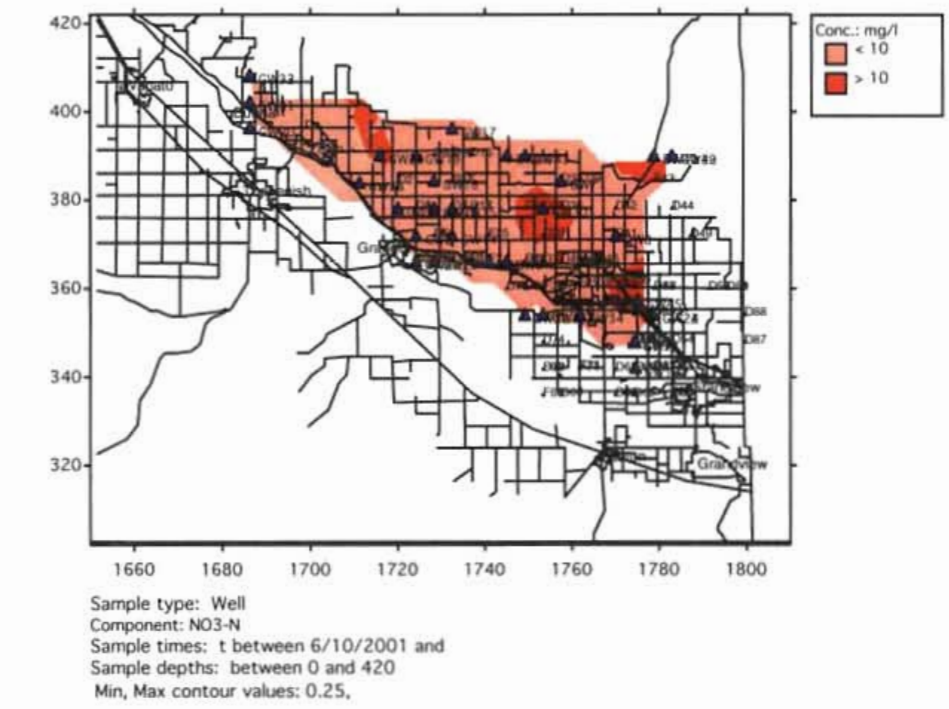
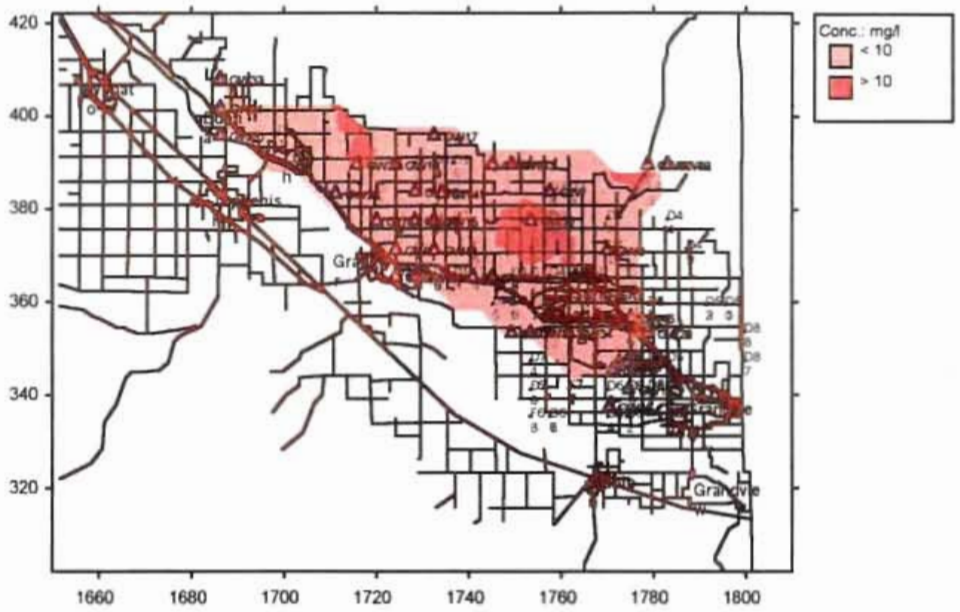
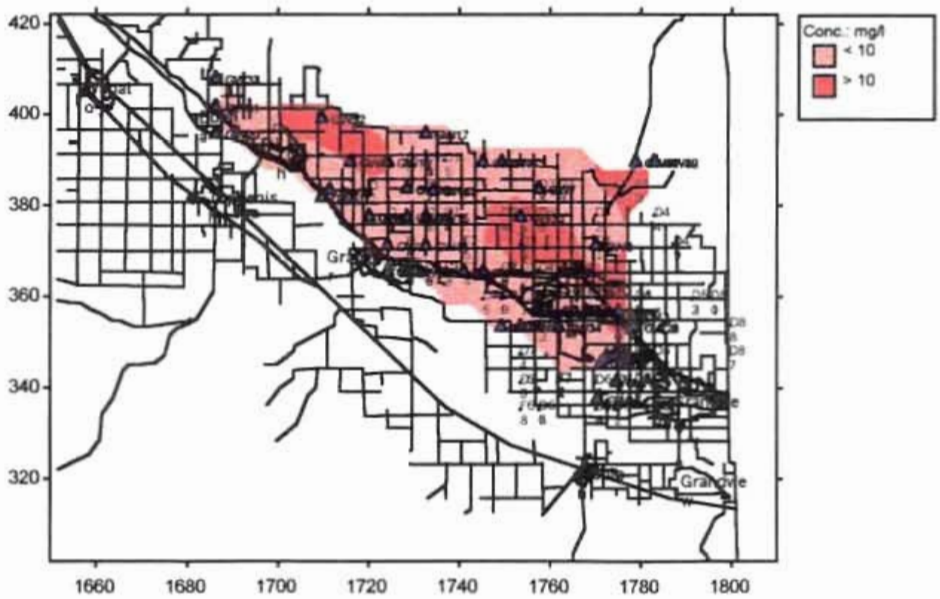


Figure 12: Contours of Mean NO_3-NO_2 Concentrations Between 6/10/01 to 9/06/01



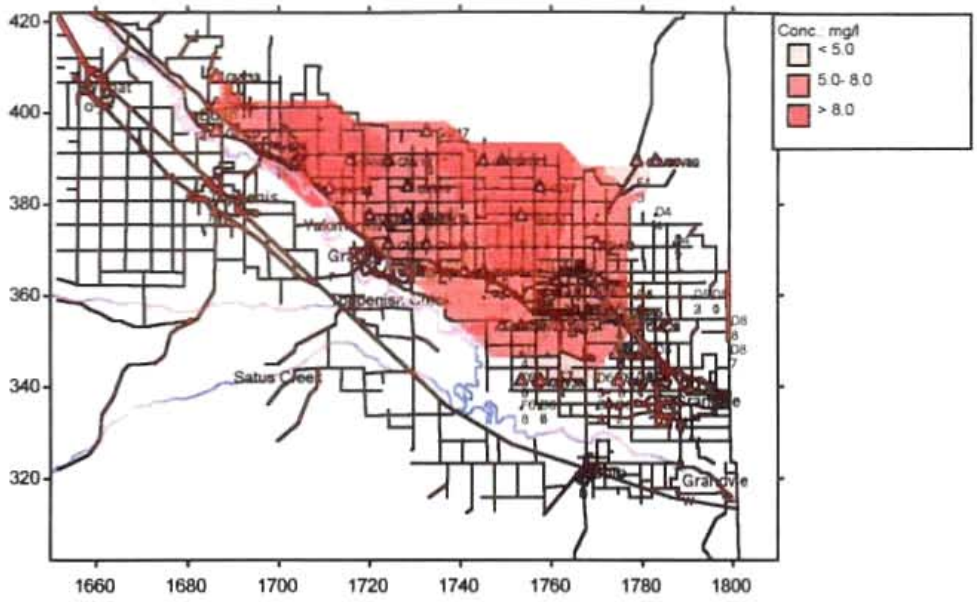
Sample type: Well
Component: NO3-N
Sample times: t between 6/10/2001 and 4/6/2002
Sample depths: between 0 and 420 ft
Min, Max contour values: 0.25, 32

Figure 13: Contours of Mean NO_3-NO_2 Concentrations Between 6/10/01 to 4/04/02



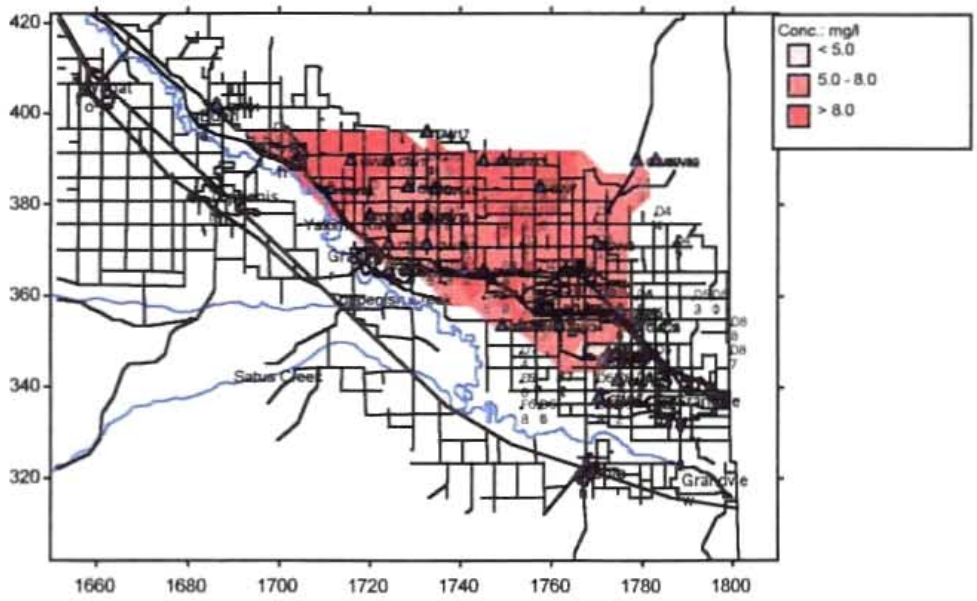
Sample type: Well
Component: NO3-N
Sample times: t between 6/10/2001 and 10/27/2002
Sample depths: between 0 and 420 ft
Min, Max contour values: 0.25, 32
Min, Max contour values: 0.25, 32

Figure 14: Contours of Mean NO_3-NO_2 Concentrations Between 6/10/01 to 10/27/02



Sample type: Well
Component: DO2
Sample times: t between 6/10/2001 and 9/6/2001
Sample depths: between 0 and 420 ft
Min, Max contour values: 0.25, 32
Min, Max contour values: 0.25, 20

Figure 15: Contours of Maximum Dissolved O_2 Concentrations Between 6/10/01 to 9/06/01



Sample type: Well
Component: DO2
Sample times: t between 9/6/2001 and 4/6/2002
Sample depths: between 0 and 420 ft
Min, Max contour values: 0.25, 20
Min, Max contour values: 0.25, 32

Figure 16: Contours of Maximum Dissolved O_2 Concentrations Between 9/06/01 to 4/06/02

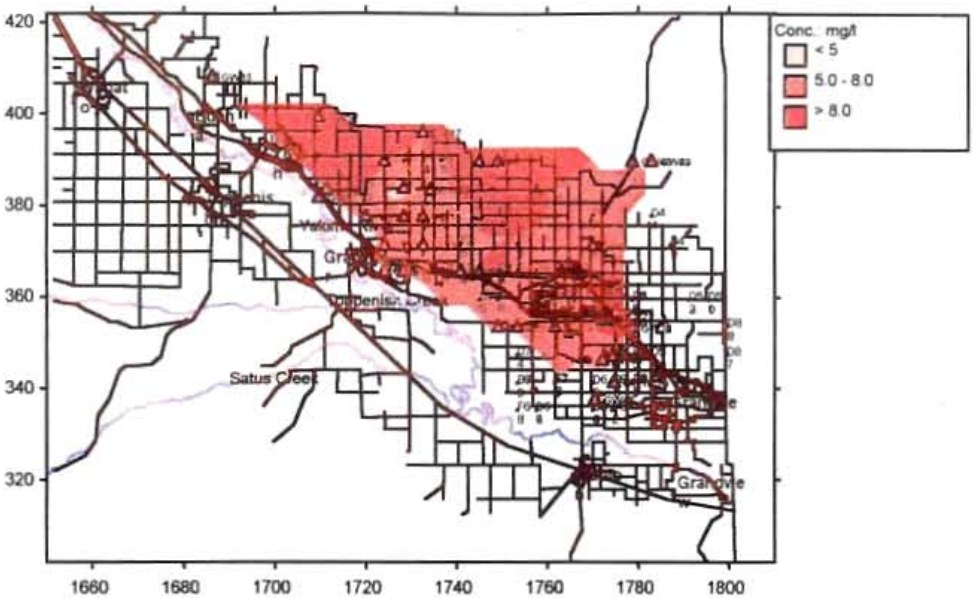


Figure 17: Contours of Maximum Dissolved O_2 Concentrations Between 4/06/02 to 10/27/02

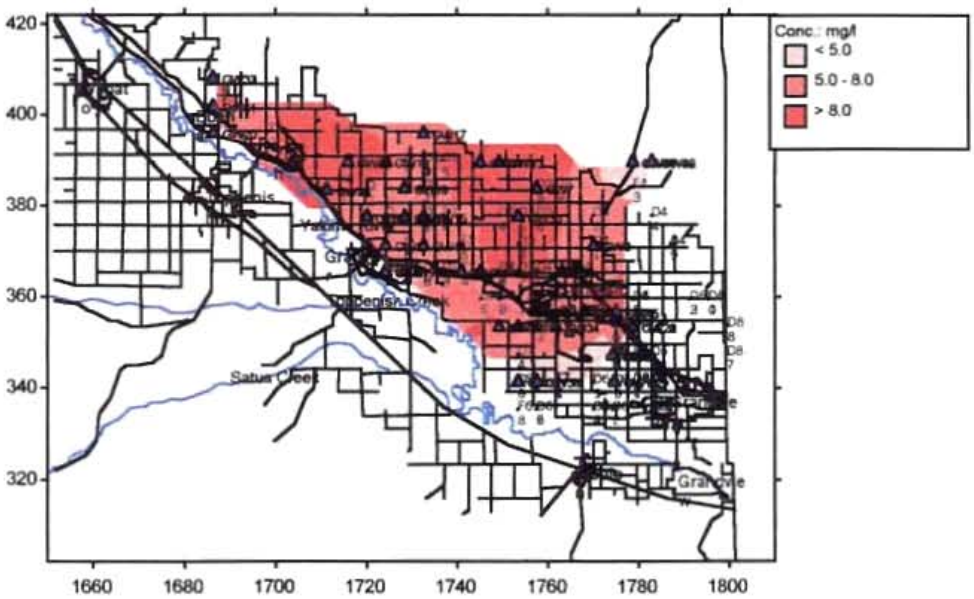


Figure 18: Contours of Mean Dissolved O_2 Concentrations Between 6/10/01 to 9/06/01